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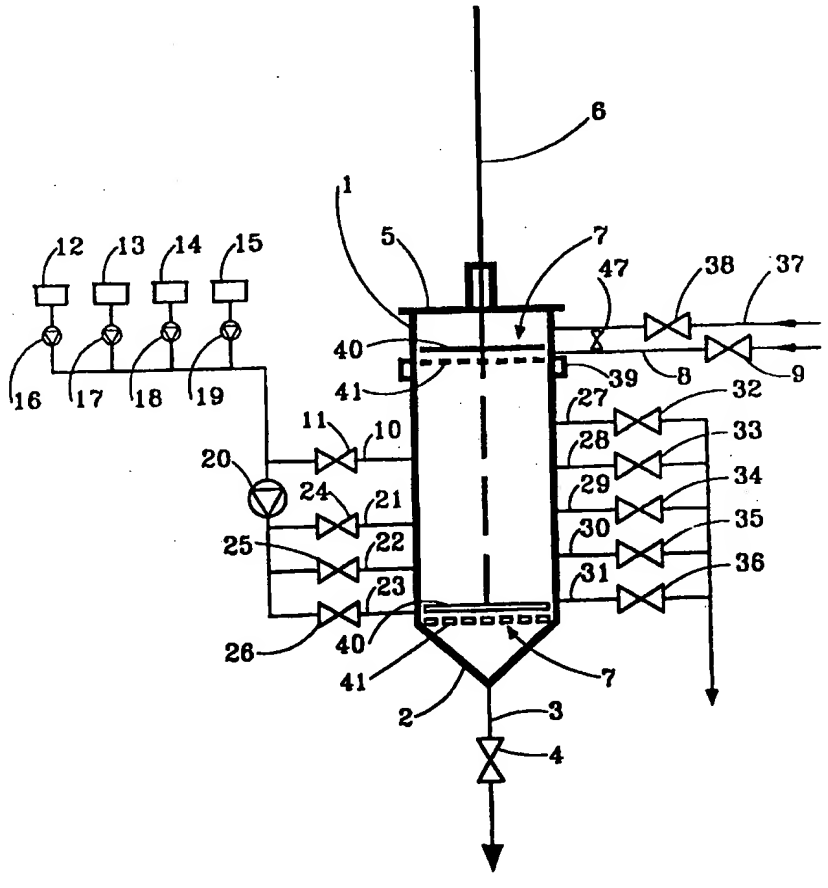
(54) Title: DEVICE FOR AND METHOD OF SEPARATING SOLIDS FROM LIQUIDS

(57) Abstract

A device for and method of separating solids from liquids, where necessary with initial emulsion breaking, precipitation, coagulation and/or flocculation treatment to convert emulsified, dissolved, and/or suspended contaminants into separable solids, comprises a treatment chamber (1) having a piston (7) movable therein between a start position in the upper part of the chamber and an end position in the lower part of the chamber, drive means outside the chamber for moving the piston, a liquid inlet (8) below the piston in the start position thereof, a treatment agent and mixing inlet (21 to 23), an outlet (3) for the discharge of solids below the piston in the end position thereof, and a liquid outlet (27 to 31) above the piston in the end position thereof, the inlets and the outlets being controlled by valves (4, 9, 24 to 26, 32 to 36), the piston (7) being permeable to the liquid but substantially impermeable to the solids.



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DEVICE FOR AND METHOD OF SEPARATING SOLIDS FROM LIQUIDS

Technical Field

This invention relates to a device for and a method of separating solids from liquids, and to a method of liquid treatment.

Background Art

While there are many large scale processes and plants available for the treatment of liquids, for example for the treatment of water for drinking and/or industrial purposes, or for the treatment of trade waste water, and in particular for the removal therefrom of dissolved substances and/or suspended solids, these are not practical or economic for many smaller businesses to install and use. As a result, water for and waste water discharges from such businesses may not meet required quality standards, containing undesirably high concentrations of contaminants; where controls are exercised, some industrial processes are not viable on a small scale because of the high cost of the water and/or waste water treatment plant.

The present invention provides a simple but highly effective device for and method of separating solids from water, waste water and other liquids, where necessary with initial emulsion breaking, precipitation, coagulation and/or flocculation treatment to convert emulsified, dissolved, and/or suspended contaminants into separable solids.

Disclosure of Invention

According to the invention, there is provided a device for separating of solids from liquids, comprising a treatment chamber having a piston movable substantially vertically therein between a start position in the upper part of the chamber and an end position in the lower part of the chamber, drive means outside the chamber for moving the piston, means for introducing liquids below the piston in the start position thereof,

means for removing solids from below the piston in the end position thereof, and a liquid outlet above the piston in the end position thereof, the piston being permeable to the liquids but substantially impermeable to the solids.

The piston suitably comprises one layer of material which is permeable to the liquid but substantially impermeable to the solids, or two layers consisting of a lower perforated plate, for example of metal or plastics, and an upper of material which is permeable to the liquid but substantially impermeable to the solids. In a two-layer piston, the upper layer is preferably spaced from the lower layer, and may comprise a woven or non-woven textile material. It will be appreciated that the invention is not limited to the use of filter cloths as the permeable layer of the piston, although such materials will be especially useful. Any material which is permeable to the liquid, but which will hold back the solids (in the desired size range) may be used. Thus, for example, a piston using porous ceramic materials, or particulate filter materials, or combinations of the two, can be use in devices and methods according to the invention.

The piston may be driven between its start and end positions (and vice versa) by a hydraulic or pneumatic ram, mounted vertically over the chamber, or by a helical screw driven by a motor, for example an electric motor with suitable reduction gearing. Alternatively, the piston may be arranged to descend by gravity, its descent being controlled by a simple hoist, which is then used to return the piston to its start position at the end of the treatment cycle. Any drive mechanism affording controlled slow descent of the piston, and enabling the piston to be recovered to its start position at the return of the treatment cycle may be employed. The speed of downward movement of the piston through the liquid will be chosen so as to be as fast as possible without the solid particles becoming so compacted on the underside of the piston that they block the permeable layer during its descent, thus preventing further piston movement. Ideally, the solids on the underside of the piston will remain of a sufficiently open structure to permit the passage of the liquid through the layer until the piston reaches the lower limit of its movement, when intense compaction is allowed to occur.

The means for removing solids may suitably comprise a spring-loaded valve which discharges automatically when a sufficient amount of solids has built up, a manually or mechanically operated sliding plate valve, or a bag valve using a tube of a flexible material which is simply twisted to close the valve and untwisted to release the solids.

The device may comprise means for spraying cleaning liquid in and/or on to the piston either during movement thereof from the end position back to the start position or when the piston is in the start position thereof. Where the piston has two layers spaced apart from each other, the device may be arranged to permit cleaning liquid to be introduced between the two layers at an appropriate point in the cycle of movement of the piston between its start and end positions or at its start position.

The device may comprise means for introducing into the liquids beneath the piston in the start position thereof one or more treating agents to cause breaking of an emulsion, precipitation of substances dissolved in the liquids, coagulation and/or flocculation of solids in the liquids. The means for introducing the treating agent or agents preferably comprises at least one pump for injecting the agent or agents into the chamber, for example through a nozzle.

The device may comprise means for a rapid mixing of the agent or agents with the liquid, and for a slow ("tapered") mixing which promotes flocculation. The means for mixing preferably comprises a circulating pump outside the chamber and a plurality of selectively opened and closed outlets and inlets from and to the chamber, whereby liquid may be drawn from the chamber through one or more of the outlets and reintroduced into the chamber through one or more of the inlets by this pump.

Two or more devices in accordance with the invention may suitably be used in concert, with some filling while others are discharging. These devices can be controlled by a single controller, with the timing of operation being so adjusted that near-continuous flow is achieved.

The invention also provides a method of separating solids from liquids, comprising introducing a solid/liquid mixture into a chamber, driving a piston downwardly in the chamber through the liquids, the piston being permeable to the liquids but substantially impermeable to the solids, compacting the separated solids beneath the piston in the lowermost part of the chamber, removing the liquids from above the piston, and removing the solids from beneath the piston.

The invention further provides a method of liquid treatment, comprising introducing a volume of the liquid into a treatment chamber, dispersing into the liquid in the chamber at least one treating agent to cause breaking of an emulsion, precipitation of substances therefrom and/or coagulation and flocculation of solids therein, driving a piston downwardly in the chamber through the liquid, the piston being permeable to the liquid but substantially impermeable to the solids, compacting the separated solids beneath the piston in the lowermost part of the chamber, removing the liquid from above the piston, and removing the solids from beneath the piston.

The liquid may be an emulsion, for example a mixture of oil and water, water being prepared for drinking and/or for industrial purposes, or trade waste water, for example from an industrial cleaning process or the like, and the treating agent can be an emulsion breaking, precipitating, coagulating and/or flocculating agent, for example for use in the removal of waste detergents. It is especially suited for the treatment of liquids in batch volumes of 0.5 to 12 m^3, but the invention is not limited to devices within this range of capacities.

Brief Description of Drawings

In the drawings, which illustrate diagrammatically exemplary embodiments of the invention:-

Figure 1 is a representation of a trade waste water treatment plant including a device in accordance with a first embodiment;

Figure 2 is a view corresponding to Figure 1, but including a device according to a second embodiment;

Figure 3 is an enlarged view of portion A of Figure 2;

Figure 4 is a representation of a device according to a third embodiment;

Figure 5 is a representation of a sludge dewatering plant including a device in accordance with a forth embodiment;

Figure 6 is a view corresponding to Figure 5, but including a device according to a fifth embodiment of the invention; and

Figure 7 is an enlarged view of portion A of Figure 6.

Detailed Description of the Illustrated Embodiments

Referring first to Figure 1, the device comprises a closed chamber 1 having a frusto-conical lower end 2 provided with an outlet for discharge of solids 3 controlled by an outlet valve device (for example a shutter) 4. The upper end of the chamber 1 is closed by a removable lid 5 (to permit maintenance and cleaning) through which passes a sealed rigid shaft 6 connected at its lower end to a piston 7. The shaft 6 is suitably driven down and up by a hydraulic ram (not shown), mounted above the chamber 1. The piston 7 consists of a frame provided with circumferential sliding seals engaging the inner cylindrical surface of the chamber 1, and a layer of a filter cloth or the like stretched across the frame. The filter cloth is chosen so as to permit the passage of liquid therethrough, but to hold back solid particles having a size above a predetermined minimum permissible in the liquid for discharge.

Liquid for treatment is introduced via input line 8 controlled by input valve 9 to the chamber 1 just below the piston 7 in its start or uppermost position. Various treating agents are added to the water in the chamber 1 via lines 21, 22 and 23 and valves 24, 25

and 26 from supply tanks 12 to 15, each having a respective dosing pump 16 to 19. For example, the first two tanks 12 and 13 may contain, respectively, acid and base for the adjustment of pH, the third tank 14 may contain a reagent for causing precipitation of substances dissolved in the liquid, and the fourth tank 15 may contain an emulsion breaking, or a coagulating and/or flocculating agent for aggregating solid particles, for example solid particles in colloidal form.

The treating agents may be mixed with the liquid inside the chamber 1 by means of a circulating pump 20 which can be caused to draw liquid from the chamber 1 via line 10 and open valve 11 and re-introduce the liquid into the chamber 1 via a selected one or more of vertically spaced inlets 21 to 23, each controlled by a respective valve 24 to 26. Preferably the inlets are arranged so that the liquid streams enter the chamber tangentially thereof. Two alternative modes of mixing can be employed by this arrangement: a rapid mixing to distribute treating agents quickly though the liquid, and a gentle mixing to promote flocculation. The gentle mixing may be accomplished by setting the control valves 11 and 24 to 26 to circulate the water in one direction only (clockwise or anti-clockwise), while the rapid mixing may be accomplished by setting these valves to discharge water in opposing directions (clockwise and anti-clockwise).

After mixing, the liquid may be allowed to settle, and then the piston 7 is driven downwardly through the liquid at a controlled rate such that the solids within the liquid are urged downwardly to settle in the frusto-conical lower end 2 of the chamber 1, the piston 7 tending to compact the solids.

While the piston 7 is in its lowermost or end position, the liquid, for example water or waste water, above the piston 7 is drawn off via vertically-spaced outlets 27 to 31 and control valves 32 to 36, to be discharged, for example to the water supply system or to the sewer or to a further treatment stage if required.

The several vertically-spaced outlets 27-31 are used to permit extraction of liquid at a selected height, for example if the piston 7 comes to rest at a higher position as a result of compacted solids.

The solids may be evacuated by means of the valve 4. This can be a non-return valve with adjustable release pressure, allowing automatic discharge of the solids when a sufficient amount has built up. It will allow the degree of dewatering to be controlled, and prevent solids compacting to such an extent that they are difficult to remove from the chamber 1. Where excessive compaction has occurred, it may be necessary to open the lower end of the chamber 1 to remove the solids, and provision may be made in the construction of the chamber 1 to facilitate this.

Washing of the piston 7 is preferably carried out at the end or beginning of each treatment cycle. This is effected by spraying back wash water on to the upper face of the piston 7, the backwash water being introduced by a line 37 connected to the upper end of the chamber 1 via a valve 38, and by the upward movement of the piston 7 through the back wash water above the piston 7. The line 37 preferably communicates with a plurality of nozzles arranged around the interior of the chamber 1. Alternatively, or additionally, wash water or liquid entering the chamber 1 for treatment may be introduced to the underside of the piston 7 via the line 8, which may also communicate with its own set of nozzles arranged around the interior of the chamber 1.

Referring now to Figure 2, in which corresponding components to those in Figure 1 are given the same reference numerals, the piston 7 consists of two layers 40 and 41 spaced vertically apart, as may be seen more clearly from Figure 3. The upper layer 40 comprises a frame 42 with a filter cloth 44 stretched across it. The frame 42 is in sliding sealing contact with the inner wall of the chamber 1 via a resilient sealing member 43, for example of a silicone rubber cord. The filter cloth 44 may be of woven, polypropylene or nylon. The lower layer 41 is in the form of a perforated plate, with each perforation being formed as a tapering conical hole 45 with its mouth opening downwardly of the piston 7. The obtuse angle of each hole 45 assists in ensuring that no clogging of the holes 45 in the plate occurs in use, and that the plate is easy to clean after use. The lower layer 41 is also in sliding sealing contact with the inner wall of the chamber 1, through a resilient seal 46, for example of a silicone rubber cord.

The use of the device with the two-layer piston, as shown in Figure 2, is essentially the same as with the device shown in Figure 1, but the cleaning operation differs. In this embodiment, the backwash water supplied through line 37 can be fed on the upper face of the piston upper layer 40 and liquid to be treated can be fed to the space between the layers 40 and 41 by means of line 8, flowing down to the chamber 1 beneath the piston 7 through the holes 45 and by-pass pipes 39, thus cleaning the holes 45 and washing out any solids which entered the space between the piston layers 40 and 41 during the prior compacting of solids.

Alternatively, clean water can be introduced between the piston layers 40 and 41 by opening a communicating valve 47, with the valve 9 closed.

Referring now to Figure 4, the device shown comprises a cylindrical body 50 having frusto-conical top and bottom end portions 51 and 52, the bottom end portion 52 having three support legs 53, 54 and 55 attached thereto to support the body 50 in use. Each leg 53, 54 and 55 is formed as a hollow vessel which can hold a supply of treating agents to be pumped therefrom, when required, by dosing pumps P3, P4 and P5.

Control of the various pumps and valves in the device, as well as movement of the piston 56, is by means of a programmable logic controller (PLC) 57, provided with inputs from appropriate sensors.

The operation of the device is as follows. Waste water is first pumped into the body 50 via pump P1 with the piston 56 fully withdrawn to the top of the body 50 (Pos 1). When the body 50 is full, a level gauge (float switch or the like) signals to the PLC 57, which in turn causes the pump P1 to stop. A circulating pump P2 is then started to recirculate the water from the base of the body 50 via line 58 back to a position in the upper part of the body. A primary coagulant (e.g. ferric sulphate or aluminium sulphate) is introduced from a storage tank in a first of the legs 53 via pump P3 to the body 50. The dose can be controlled (by the PLC 57) by the length of time for which the pump P3 is operated. A pH probe 60 in the line 58 monitors the hydrogen ion concentration in the water as it circulates, and after a predetermined interval of processing with the

coagulant, the pH is readjusted by the addition of an alkali, for example sodium hydroxide solution, from the second of the legs 54 via pump P4, the pump being operated until the probe detects the desired value (typically just below pH7) again. At this stage, a predetermined volume of a polymer flocculant solution is introduced from the third of the leg tanks 55 via pump P5, to cause the effluent within the body 50 to flocculate. Again the recirculation or mixing at this stage using pump P2 is the subject of a timed process under the control of the PLC 57.

After the predetermined time has elapsed, the pump P2 is stopped and a dwell time is initiated, allowing the flocs to form and to start to precipitate in the body 50. The piston 56 will then start to fall. Once the piston reaches the lowermost or end position (Pos 3), it activates a sensor (not shown) which signals to the PLC 57 to open the valves V1, V2, V3 and V4, allowing the clean water fraction to be drained away, leaving the sludge below the membrane in the piston 56. After the water has completely drained away, the lowermost valve V5 is opened to allow discharge of the sludge (it will be appreciated that discharge of the sludge may only be necessary once every few strokes of the piston 56, when a sufficient amount of sludge has built up).

After completion of this cycle, the valve V5 will stay open while the piston 56 returns back to its starting position Pos 1, to avoid the creation of a vacuum. The valve V5 closes when the piston reaches Pos 1, and an automatic backwash is carried out by opening valve V6 to allow backwash water to be sprayed on to the upper surface of the piston 56 from a ring of nozzles 61 around the inside of the upper frusto-conical portion 51 of the body 50. The cycle can then recommence with the filling of the body 50 with the next batch of waste water.

It will be appreciated that, while the device has been described in connection with the treatment of water, it may equally be used for other liquids or liquid mixtures in which solids are suspended, or in which dissolved solids can be precipitated out for removal.

The device is especially suited to the treatment of liquids containing fibrous or particulate contaminants, and emulsions.

Referring now to Figure 5, the device comprises a closed chamber 1 having a frusto-conical lower end 2 provided with a solids outlet 3 controlled by an outlet valve device (for example a shutter) 4. The upper end of the chamber 1 is closed by a removable lid 5 (to permit maintenance and cleaning) through which passes a sealed rigid shaft 6 connected at its lower end to a piston 7. The shaft 6 is suitably driven down and up by a hydraulic ram (not shown), mounted above the chamber 1. The piston 7 consists of a frame with a layer of a filter cloth or the like stretched across it and provided with circumferential sliding seals engaging the inner cylindrical surface of the chamber 1. The filter cloth is chosen so as to permit the passage of liquid therethrough, but to hold back solid particles having a size above a predetermined minimum permissible in the liquid for discharge.

Solids containing liquids, for example sludge which needs dewatering, are introduced via input line 8 controlled by input valve 9 to the chamber 1 below the piston 7 in its start or uppermost position and then the piston 7 is driven downwardly at a controlled rate such that the solids are urged downwardly to be compacted against the frusto-conical lower end 2 of the chamber 1. While the piston 7 is in its lowermost or end position, the liquid, for example water, above the piston 7 is drawn off via vertically-spaced outlets 10 to 14 and control valves 15 to 19, to be discharged, for example to the sewer or to a further treatment stage if required.

The several vertically-spaced outlets 10 to 14 are used to permit extraction of liquid at a selected height, for example if the piston 7 comes to rest at a higher position as a result of compacted solids. The solids may be evacuated by means of valve 4. This is suitably a non-return valve with adjustable release pressure, allowing automatic discharge of the solids as they are compacted. It will allow the degree of liquid removal to be controlled, and prevent solids compacting to such an extent that they are difficult to remove from the chamber 1.

Washing of the piston 7 is preferably carried out at the end or beginning of each dewatering cycle. This is effected by spraying wash water on to the upper face of the piston 7, the backwash water being introduced by a line 22 connected to the upper end of the chamber 1 via a valve 23, and by the upward movement of the piston 7 through the wash water in the chamber 1. The line 22 preferably communicates with a plurality of nozzles arranged around the interior of the chamber 1. Alternatively, or additionally, wash water may be introduced on the underside of the piston 7 via a valve 21 and line 20, which may also communicate with its own set of nozzles arranged around the interior of the chamber 1.

Referring now to Figure 6, in which corresponding components to those in Figure 5 are given the same reference numerals, the piston 7 consists of two layers 25 and 26 spaced vertically apart, as may be seen more clearly from Figure 7. The upper layer 25 comprises a frame 27, with a filter cloth 29 stretched across it. The frame 27 is in sliding sealing contact with the inner wall of the chamber 1 via a resilient sealing member 28, for example a silicone rubber cord. The filter cloth 29 may be of woven polypropylene or nylon. The lower layer 26 is in the form of a perforated plate, with each perforation being formed as a tapering conical hole 30 with its mouth opening downwardly of the piston 7. The obtuse angle of each hole 30 assists in ensuring that no clogging of the holes 30 in the plate occurs in use, and that the plate is easy to clean after use. The lower layer 26 is also in sliding sealing contact with the inner wall of the chamber 1, through a resilient seal 31, for example of a silicone rubber cord.

The use of the device with the two-layer piston as shown in Figure 6 is essentially the same as with the device shown in Figure 5, but the cleaning operation differs. In this embodiment, the backwash water is supplied to the head of the piston 7 and to the space between the layers 25 and 26 by means of lines 20 and 22, via valves 21 and 23. By-pass pipes 24 permit water to flow from the space between the piston layers 25 and 26 to the chamber 1 beneath the piston 7.

Example of Modes for Carrying Out the Invention

Referring now again to Figure 2 and Figure 3, a mode for carrying out the invention comprises the following sequence of events, when starting with piston 7 in its start (uppermost) position, valves 4, 9, 32 to 36, 38 and 47 closed, and pumps 16 to 19 and 20 stopped:-

liquid, for example water, waste water or an emulsion, is introduced into the chamber 1 beneath the piston 7 through the line 8, via the valve 9, and the plurality of by-pass pipes 39 and holes 45;

the circulating pump 20 is started, and appropriate inlet valves 24 to 26, together with valve 11, are opened to start rapid mixing;

the dosing system 12 to 19 injects chemicals for the breaking of an emulsion, precipitation, coagulation and/or flocculation of substances in the liquid (i.e. one or both of dosing pumps 18 and 19 is/are started to pump the chemicals into the circulation mixing system 10, 11 and 20 to 26);

the mixing system 10, 11 and 20 to 26 rapidly mixes the liquid in the chamber 1 until the chemicals are thoroughly dispersed, and is then switched to a gentle ("tapered") mixing mode to expedite flocculation (pump 20 is slowed down and/or the valves 24 to 26 are set to ensure that the flows in the chamber 1 are all in the same direction);

after sufficient time to permit completion of flocculation, the slow mixing is stopped and the piston 7 is moved slowly downwards in the chamber 1 towards its end position, as illustrated by the broken line representation of the shaft 6. This allows liquid to be displaced through the piston 7 to the space above the piston 7, while confining the solids to the space below the piston 7;

if the valve 4 is a non-return type, compacting of the solids results in discharge of the solids through this valve, but if the valve 4 is not a non-return type, the solids are discharged through this valve periodically, after suitable accumulation of solids. Discharge of the solids may also be achieved by opening the end of the chamber 1;

the mixing system 10, 11 and 20 to 26 begins ra[illegible] mixing of the liquid remaining above the piston 7 in the chamber 1;

the liquid in the chamber 1 is then tested, for example by means of probes in the chamber 1 or in the mixing system 10, 11 and 20 to 26 outside the chamber 1, and if the liquid is within acceptable limits for discharge (e.g. pH between 7 and 10), the mixing system 10, 11 and 20 to 26 stops and valves 32 to 36 open to discharge the liquid from the chamber 1;

if the liquid is not within acceptable limits for discharge, the dosing system 12 to 19 adds acid or base from tanks 12 or 13 using pumps 16 or 17 to correct the pH (or other chemicals to correct other deficiencies in liquid quality), and then the mixing is stopped and the liquid discharged.

Referring now again to Figure 6 and Figure 7, a mode for carrying out the invention while removing liquids from solids, for example dewatering the sludge, comprises the following sequence of events, when starting with piston 7 in its uppermost position, and valves 4, 9, 15 to 19, 21 and 23 closed:-

a mixture of solids and liquids is introduced into the chamber 1 beneath the piston 7 through the line 8;

the piston 7 is moved slowly downwards in the chamber 1 towards its end position, as illustrated by the broken line representation of the shaft 6. This allows liquid to be displaced through the piston 7 to the space above the piston 7, while confining the solids to the space below the piston 7;

compacting the solids results in discharge of the solids through the non-return type valve 4;

valves 15 to 19 open to discharge the liquid from the chamber 1, above the piston 7.

Industrial Applicability

The main industrial applicability of the device and method according to the invention is water, trade waste water and sewage treatment. This device and method may be used for any water and waste water for which an effective chemical treatment, such as breaking of an emulsion, precipitation, coagulation and/or flocculation, is available. With the broad range of currently available water treatment chemicals, the device and method is suitable for removal of (1) dissolved substances, (2) suspended solids, (3) emulsified oils, and (4) colour from trade waste water and water being prepared for drinking and industrial purposes.

The device and method, in their simpler forms, may be used solely for dewatering of sludge.

The device and method may have applications in the removal of dissolved substances and suspended solids in liquids other than water.

CLAIMS

1. A device for separating of solids from liquids, comprising a treatment chamber having a piston movable substantially vertically therein between a start position in the upper part of the chamber and an end position in the lower part of the chamber, drive means outside the chamber for moving the piston, means for introducing liquids below the piston in the start position thereof, means for removing solids from below the piston in the end position thereof, and a liquid outlet above the piston in the end position thereof, the piston being permeable to the liquids but substantially impermeable to the solids.

2. A device according to Claim 1, wherein the piston comprises one layer of a porous material which is permeable to the liquids but substantially impermeable to the solids.

3. A device according to Claim 2, wherein the piston layer comprises a woven or non-woven textile material, porous ceramic materials, particulate filter materials or combinations of the four.

4. A device according to Claim 1, wherein the piston comprises two layers of which the lower is of a perforated plate and the upper of a porous material which is permeable to the liquids but substantially impermeable to the solids.

5. A device according to Claim 4, wherein the upper layer is spaced from the lower layer.

6. A device according to Claim 4 or 5, wherein the upper layer comprises a woven or non-woven textile material, porous ceramic materials, particulate filter materials or combinations of the four.

7. A device according to any preceding claim, comprising means for spraying cleaning liquid in and/or on to the piston either during movement thereof from the end position back to the start position or when the piston is in the start position thereof.

8. A device according to any preceding claim, comprising means for introducing into the liquids beneath the piston in the start position thereof one or more treating agents to cause breaking of an emulsion, precipitation of substances dissolved in the liquids, coagulation and/or flocculation of solids in the liquids.

9. A device according to Claim 8, wherein the means for introducing the treating agent or agents comprises a pump for injecting the agent or agents into the chamber.

10. A device according to any preceding claim, comprising means for mixing the agent or agents with the liquids and for promoting flocculation.

11. A device according to Claim 10, wherein the mixing means comprises a circulating pump outside the chamber and a plurality of outlets and inlets from and to the chamber selectively opened and/or closed, whereby liquids may be drawn from the chamber through a selected one or more of the outlets and reintroduced into the chamber through one or more of the inlets by the pump.

12. A method of separating solids from liquids, comprising introducing a solid/liquid mixture into a chamber, driving a piston downwardly in the chamber through the liquids, the piston being permeable to the liquids but substantially impermeable to the solids, compacting the separated solids beneath the piston in the lowermost part of the chamber, removing the liquids from above the piston, and removing the solids from beneath the piston.

13. A method of liquid treatment. comprising introducing a volume of the liquid into a treatment chamber, dispersing into the liquid in the chamber at least one treating agent to cause breaking of an emulsion, precipitation of substances therefrom and/or coagulation and flocculation of solids therein, driving a piston downwardly in the

chamber through the liquid, the piston being permeable to the liquid but substantially impermeable to the solids, compacting the separated solids beneath the piston in the lowermost part of the chamber, removing the liquid from above the piston, and removing the solids from beneath the piston.

14. A method according to Claim 13, wherein the liquid is an emulsion, water or waste water.

15. A method according to Claim 13 or 14, wherein the treating agent is a breaking of an emulsion, precipitating, coagulating and/or flocculating agent.

16. A device for separating solids from liquids, substantially as described with reference to, or as shown in, the drawings.

17. A method of separating solids from liquids, substantially as described with reference to the drawings.

18. A method of liquid treatment, substantially as described with reference to the drawings.

AMENDED CLAIMS

[received by the International Bureau on 14 October 1996 (14.10.96); original claims 1-18 replaced by amended claims 1-16 (3 pages)]

1. A device for separating emulsions, dissolved substances and/or suspended solids from liquids, comprising a treatment chamber having a piston movable substantially vertically therein between a start position in the upper part of the chamber and an end position in the lower part of the chamber, drive means outside the chamber for moving the piston, means for introducing liquids below the piston in the start position thereof, means for introducing into the liquids beneath the piston in the start position thereof one or more treating agents to cause breaking of an emulsion, precipitation of substances dissolved in the liquids, coagulation and/or flocculation of solids in the liquids, mixing means for mixing the agent or agents with the liquids and for promoting flocculation, means for removing solids from below the piston in the end position thereof, and a liquid outlet above the piston in the end position thereof, the piston being permeable to the liquids but substantially impermeable to the solids.

2. A device according to Claim 1, wherein the piston comprises one layer of a porous material which is permeable to the liquids but substantially impermeable to the solids.

3. A device according to Claim 2, wherein the piston layer comprises a woven or non-woven textile material, porous ceramic materials, particulate filter materials or combinations of the four.

4. A device according to Claim 1, wherein the piston comprises two layers of which the lower is of a perforated plate and the upper of a porous material which is permeable to the liquids but substantially impermeable to the solids.

5. A device according to Claim 4, wherein the upper layer is spaced from the lower layer.

6. A device according to Claim 4 or 5, wherein the upper layer comprises a woven or non-woven textile material, porous ceramic materials, particulate filter materials or combinations of the four.

7. A device according to any preceding claim, comprising means for spraying cleaning liquid between piston layers and/or on both sides of the piston either during movement thereof from the end position back to the start position or when the piston is in the start position thereof.

8. A device according to Claim 1, wherein the means for introducing the treating agent or agents comprises a pump for injecting the agent or agents into the chamber.

9. A device according to Claim 1, wherein the mixing means comprises a circulating pump outside the chamber and a plurality of outlets and inlets from and to the chamber selectively opened and/or closed, whereby liquids may be drawn from the chamber through a selected one or more of the outlets and reintroduced into the chamber through one or more of the inlets by the pump.

10. A device according to Claim 1, wherein the liquid outlet comprises several vertically-spaced drains placed on the chamber wall above the piston in the lowermost position thereof.

11. A device according to Claim 1, wherein the means for removing solids from below the piston comprise a non-return type valve which discharges automatically during a downward movement of the piston, when a sufficient amount of solids has built up.

12. A method of liquid treatment, comprising introducing a volume of the liquid into a treatment chamber, dispersing into the liquid in the chamber at least one treating agent to cause breaking of an emulsion, precipitation of dissolved substances therefrom and/or coagulation and flocculation of solids therein, driving a piston downwardly in the chamber through the liquid, the piston being permeable to the liquid but substantially impermeable to the solids, compacting the separated solids beneath the piston in the lowermost part of the chamber, removing the liquid from above the piston, and removing the solids from beneath the piston.

13. A method according to Claim 12, wherein the liquid is an emulsion, water or waste water.

14. A method according to Claim 12 or 13, wherein the treating agent is a breaking of an emulsion, precipitating, coagulating and/or flocculating agent.

15. A device for separating emulsions, dissolved substances and/or suspended solids from liquids, substantially as described with reference to, or as shown in, the drawings.

16. A method of liquid treatment, substantially as described with reference to the drawings.

Statement under Article 19

The original claims have been amended as a result of the International Search Report of 14 August 1996, in order to emphasise the difference between DEVICE FOR AND METHOD OF SEPARATING SOLIDS FROM LIQUIDS, and devices and methods from four patents cited in this report.

There is a fundamental difference in concept between DEVICE FOR AND METHOD OF SEPARATING SOLIDS FROM LIQUIDS and devices and methods described in all four cited patents, viz. **DEVICE FOR AND METHOD OF SEPARATING SOLIDS FROM LIQUIDS, unlike the others, is not a filter**. With its chemical dosing and mixing means, which the others do not have, DEVICE FOR AND METHOD OF SEPARATING SOLIDS FROM LIQUIDS supports different physical-chemical reactions (precipitation, breaking of emulsions, coagulation, flocculation) and then, it *does not filter* solids from *contaminated* liquids, but it **provides, in the form of the piston, a physical boundary (barrier, edge) between flocculated solids and *clean* water**. This allows for the discharge of solids and liquids in two homogeneous streams explicitly isolated from each other.

There are a number of practical and very important implications arising from this difference, e.g.

1. DEVICE FOR AND METHOD OF SEPARATING SOLIDS FROM LIQUIDS is not limited to the removal of suspended solids, but with numerous water treatment chemicals available nowadays, it may also separate: (1) dissolved substances, by carrying initial precipitation, (2) oils, with initial breaking of emulsions, and (3) non-filtrable, highly dispersed, colloidal solids which are coagulated and flocculated inside DEVICE FOR AND METHOD OF SEPARATING SOLIDS FROM LIQUIDS prior to separation;

2. the movement of the piston of DEVICE FOR AND METHOD OF SEPARATING SOLIDS FROM LIQUIDS through liquid is much faster. Devices using a piston as a filtrating element may be very slow in operation: in cases of a fine filtration of highly dispersed solids, the movement of a piston with a relatively small area may take several hours, thus making these devices impractical.

3. the piston of DEVICE FOR AND METHOD OF SEPARATING SOLIDS FROM LIQUIDS is no or much less prone for clogging. This, together with the means for cleaning the piston which the devices from the four patents do not have and/or cannot have, makes the DEVICE FOR AND METHOD OF SEPARATING SOLIDS FROM LIQUIDS much more functional.

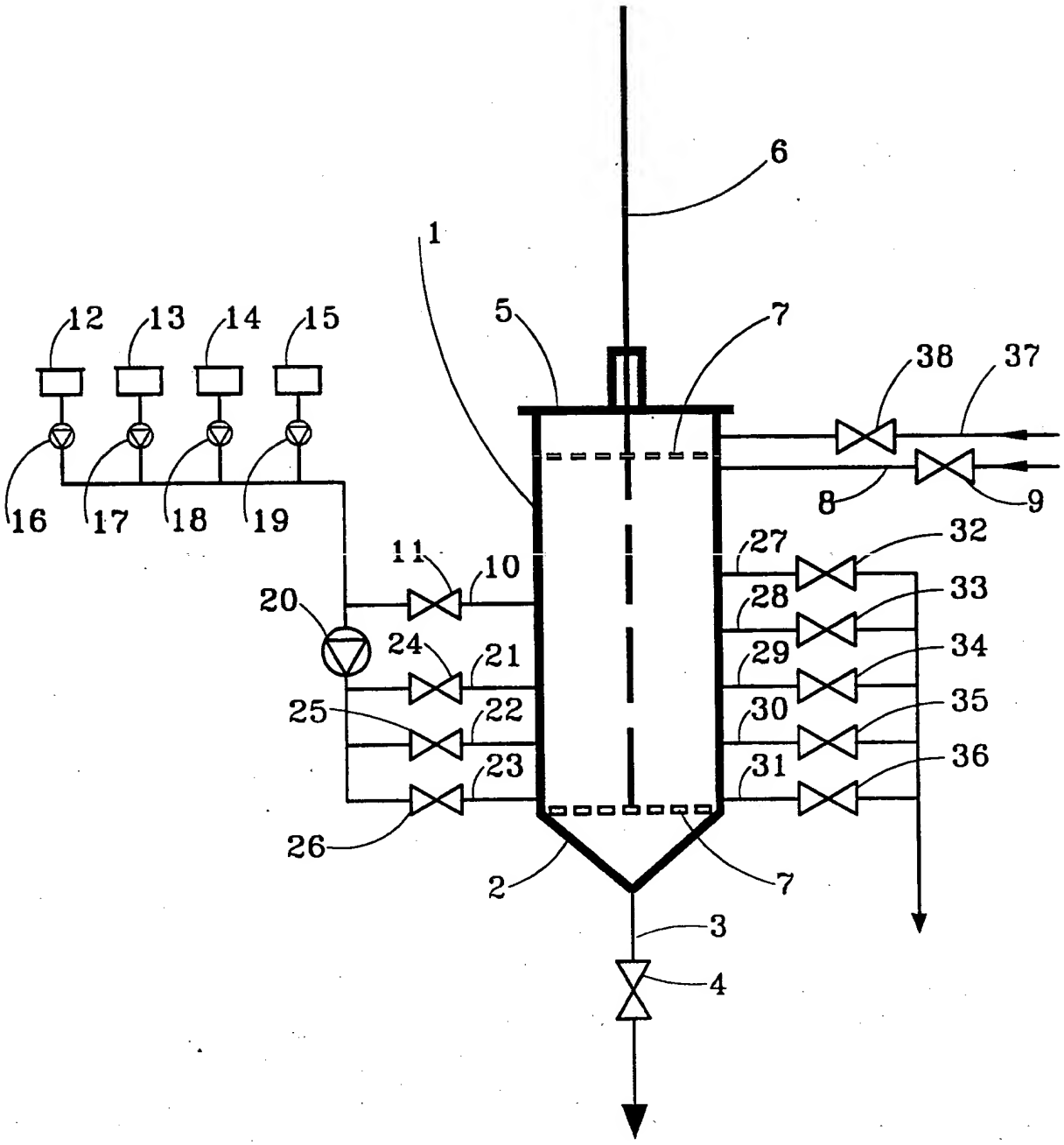
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Fig. 1

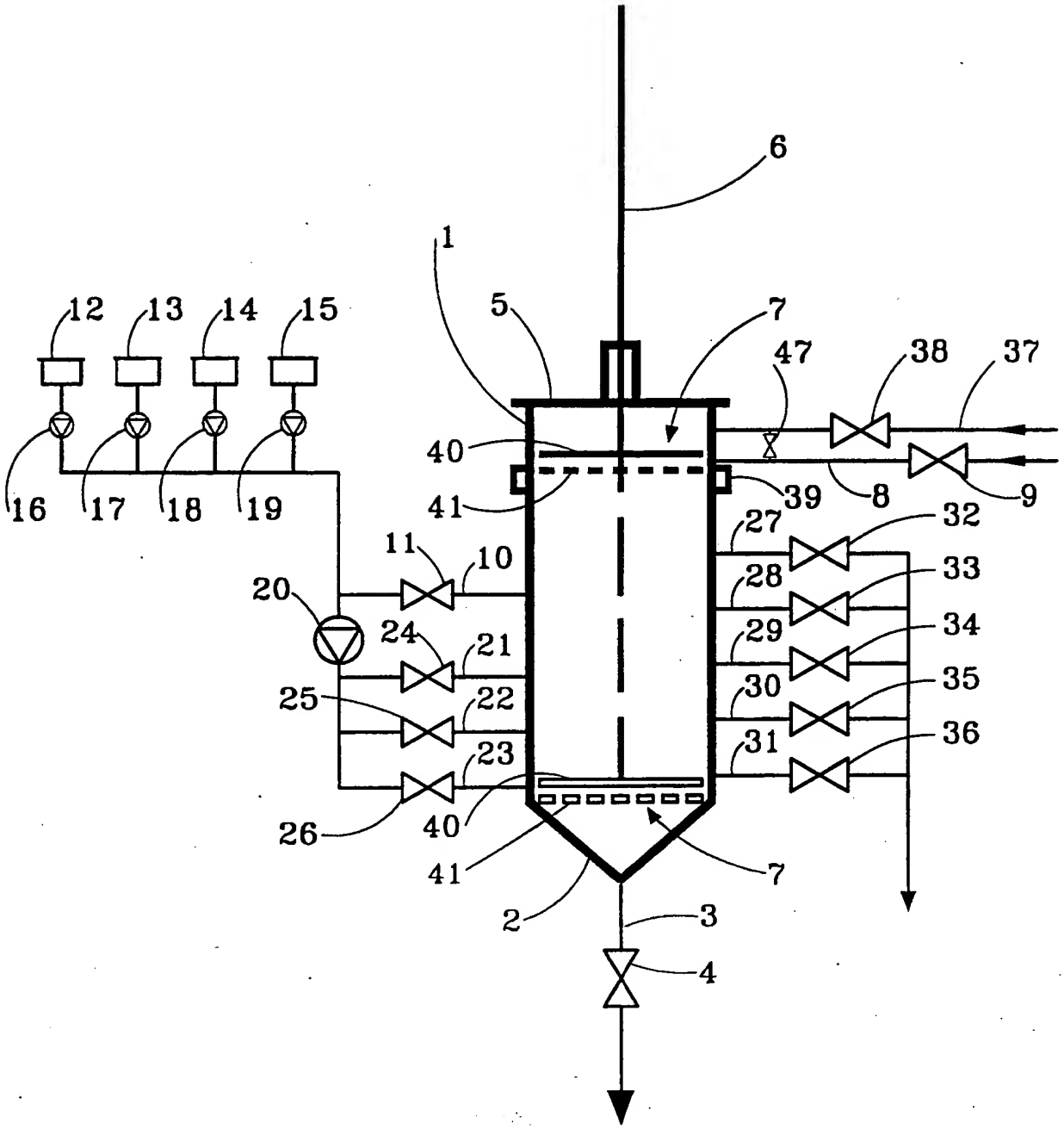
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Fig. 2

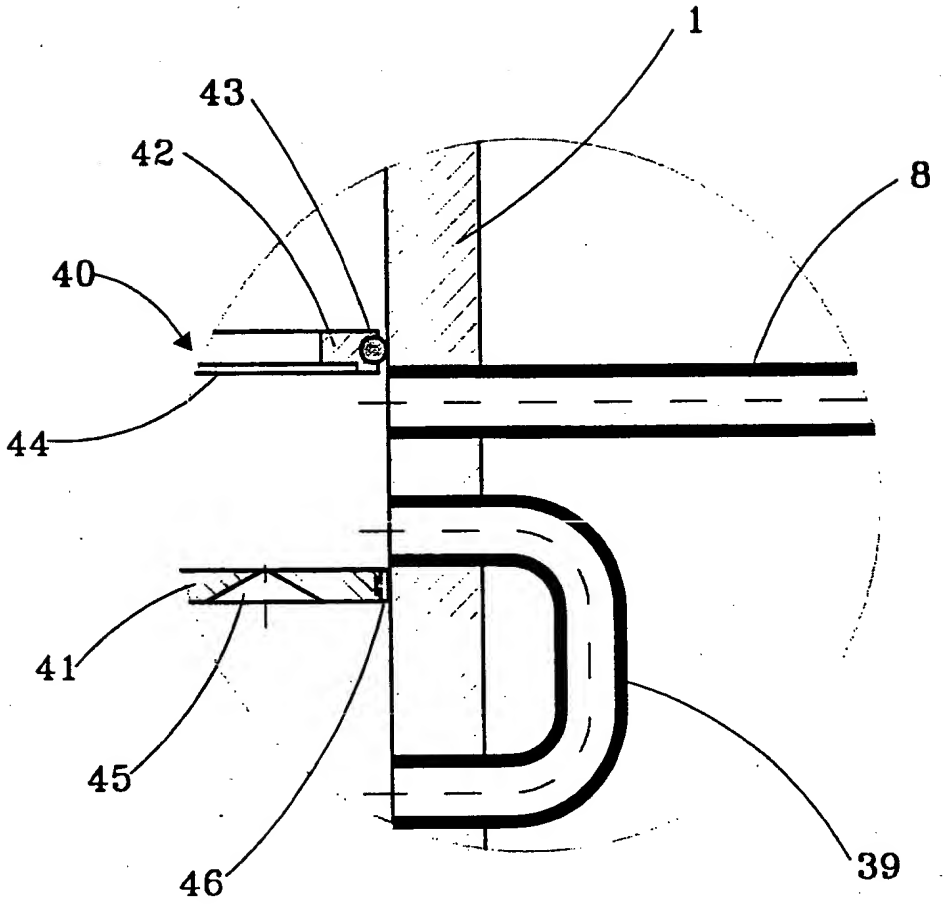
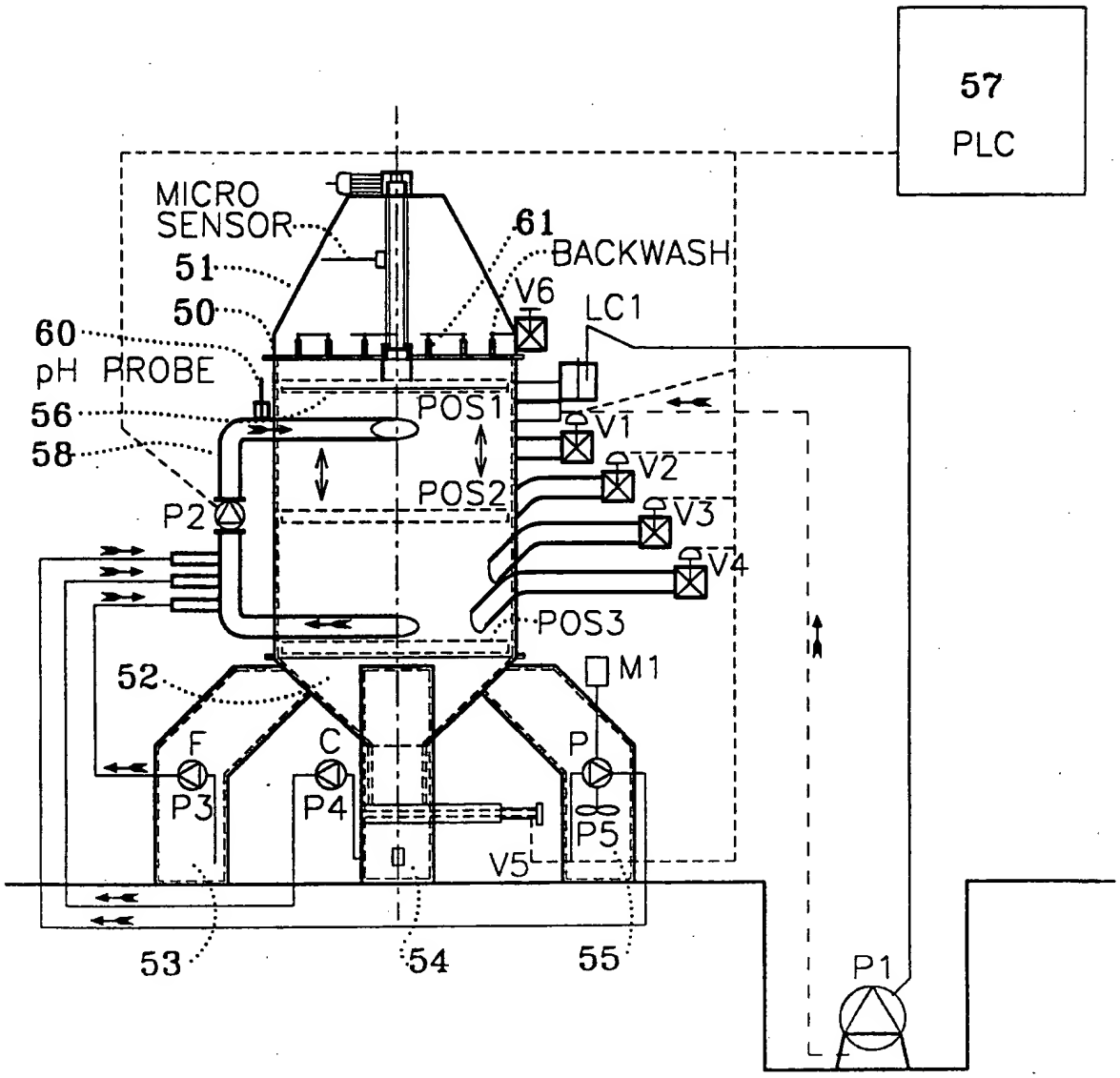


Fig. 3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V2
V3
V4
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Fig. 4

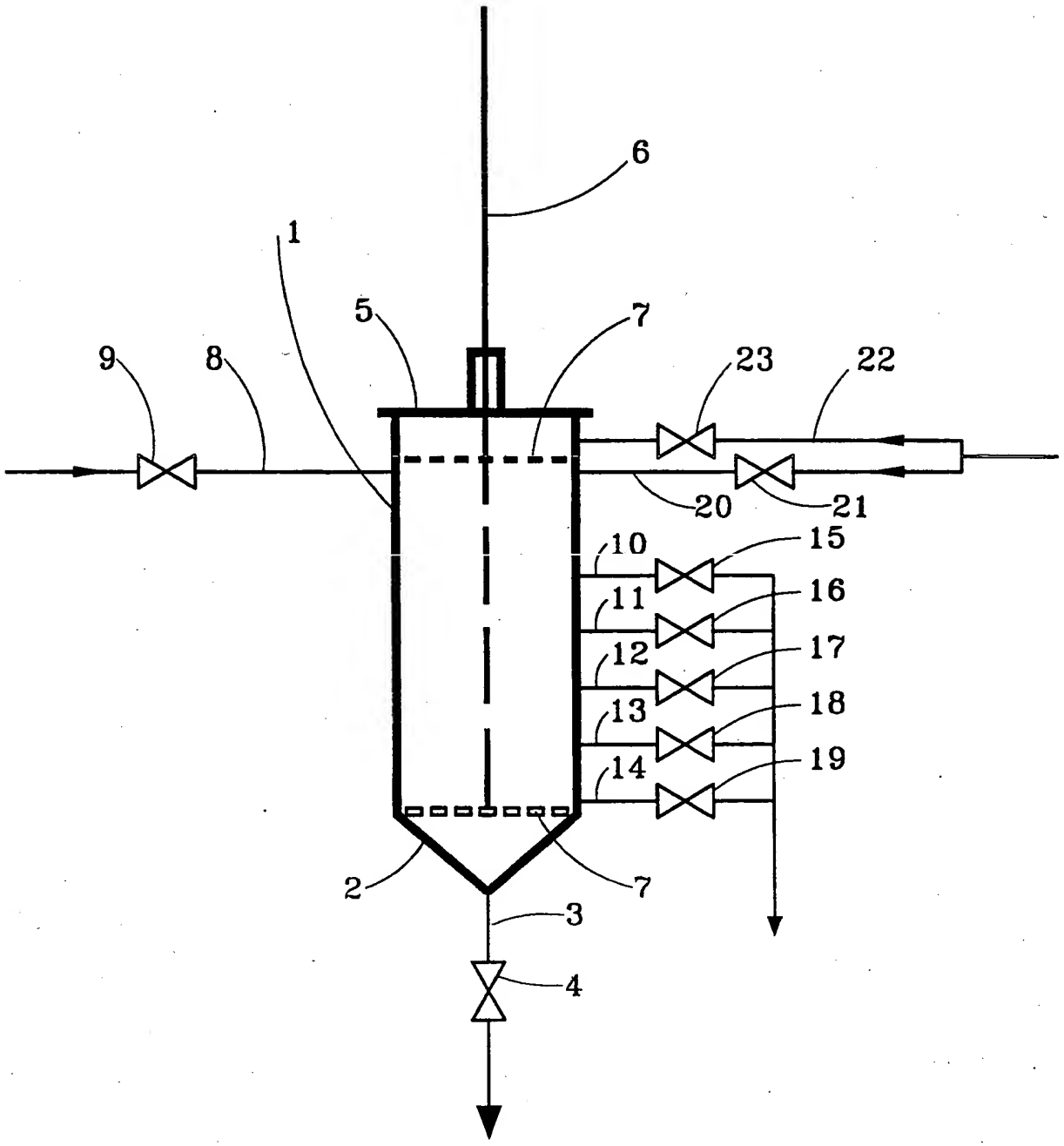

Fig. 5

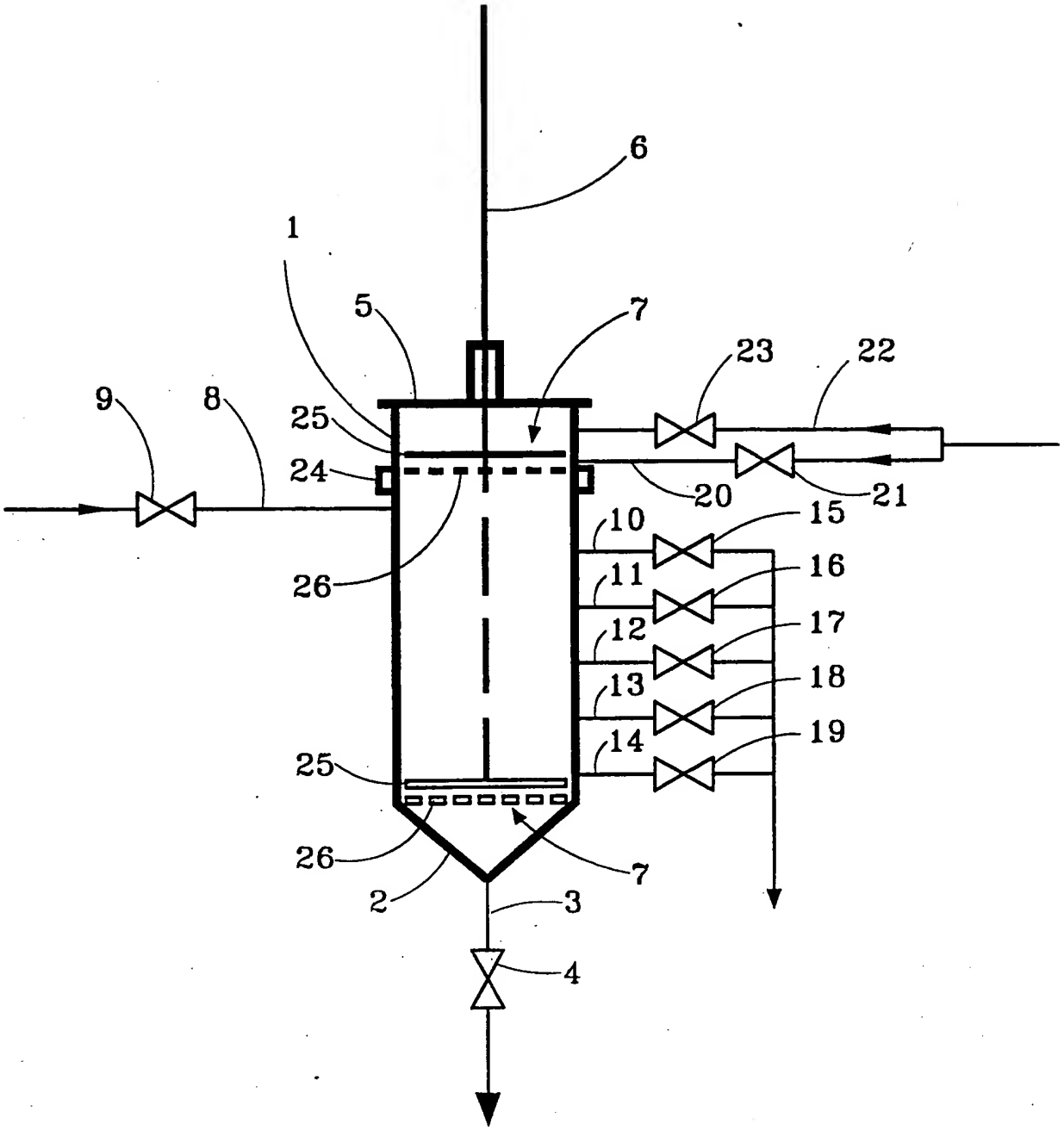

Fig. 6

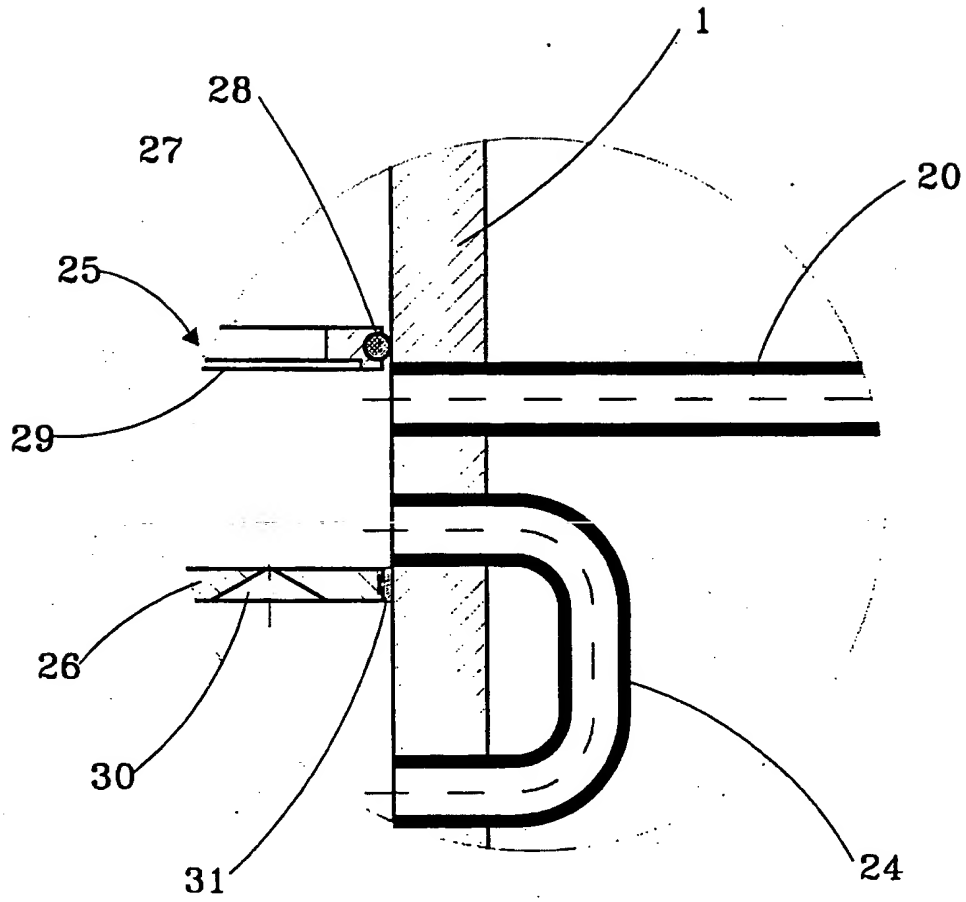

Fig. 7

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/AU 96/00277

A. CLASSIFICATION OF SUBJECT MATTER

Int Cl[6]: B01D 33/01

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC B01D 33/01, 33/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DERWENT

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5364539 A (CASTAGNO et al) 15 November 1994 See column 2 line 60 - column 5 line 4 and drawing figures 1-8	1-3, 12
X, A	US 5277109 A (MUENCH) 11 January 1994 See column 1 line 54 - column 2 line 4 and drawings	1-3, 12
X	US 4208188 A (DICK, Jr) 17 June 1980 See claims and figure 10	1-5, 12

[X] Further documents are listed in the continuation of Box C

[X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
9 August 1996

Date of mailing of the international search report
14 AUG 1996

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INTERNATIONAL SEARCH REPORT

International Application No.
PCT/AU 96/00277

C (Continuation) **DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication. where appropriate, of the relevant passages	Relevant to claim No.
X, A	Derwent Abstract Accession No. 88-034750/05, Classes D15 J01, SU 1318250 A (TROITSKI) 23 June 1987 Abstract	1-6, 12

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No.
PCT/AU 96/00277

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	5364539	DE	4345018	GB	2275000	IT	94730069
		NL	9302286				
US	4208188	CA	1119406	JP	55125199		

END OF ANNEX